General

Guideline Title

ACR Appropriateness Criteria® focal neurologic deficit.

Bibliographic Source(s)

Wippold FJ, Cornelius RS, Aiken AH, Amin-Hanjani S, Berger KL, Broderick DF, Davis PC, Douglas AC, Hoh BL, Mechtler LL, Smirniotopoulos JG, Expert Panel on Neurologic Imaging. ACR Appropriateness CriteriaÂ® focal neurologic deficit. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 11 p. [44 references]

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Wippold FJ II, Brunberg JA, Cornelius RS, Davis PC, De La Paz RL, Dormont D, Gray L, Jordan JE, Mukherji SK, Seidenwurm DJ, Turski PA, Zimmerman RD, Sloan MA, Expert Panel on Neurologic Imaging. ACR Appropriateness Criteria® focal neurologic deficit. [online publication]. Reston (VA): American College of Radiology (ACR); 2008. 11 p. [41 references]

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Clinical Condition: Focal Neurologic Deficit

Variant 1: Single focal neurologic deficit, acute onset, stable, or incompletely resolving.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without or without and with contrast	8	Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses. See statement regarding contrast in text under "Anticipated Exceptions."	O
CT head without contrast	8	Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses.	☢☢☢
MRI head without contrast	7		O
MRI head without and with contrast	7	See statement regarding contrast in text under	O

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

*Relative

Radiologic Procedure	Rating	Comments	RRL*
contrast "Anticipated Exceptions."			
MRA head and neck without contrast	7		O
CTA head and neck with contrast	7		☢☢☢
CT head perfusion with contrast	7		☢☢☢
MRI head perfusion with contrast	7	See statement regarding contrast in text under "Anticipated Exceptions."	O
CT head without and with contrast	5	If MRI is unavailable or contraindicated. Consider CT perfusion.	☢☢☢
CT head with contrast	4		☢☢☢
MR spectroscopy head without contrast	4		O
MRI functional (fMRI) head without contrast	3		O
Tc-99m HMPAO SPECT head	3	For problem solving in HIV/AIDS.	☢☢☢☢
Arteriography cervicocerebral	3	For problem solving.	☢☢☢
FDG-PET/CT head	2		☢☢☢☢
Thallium-201 SPECT head	2	For problem solving in HIV/AIDS.	☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Single focal neurologic deficit, acute onset, completely resolving.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	8	Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses. See statement regarding contrast in text under "Anticipated Exceptions."	O
CT head without contrast	8	Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses.	☢☢☢
MRI head without contrast	7		O
MRA head and neck without and with contrast	7	See statement regarding contrast in text under "Anticipated Exceptions."	O
MRA head and neck without contrast	7		O
CTA head and neck with contrast	7		☢☢☢
CT head without and with contrast	6	If MRI is unavailable or contraindicated. Consider CT perfusion.	☢☢☢
CT head with contrast	4		☢☢☢
CT head perfusion with contrast	4		☢☢☢
MRI head perfusion with contrast	4	See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI functional (fMRI) head without contrast	3		O
MR spectroscopy head without contrast	3		O
Tc-99m HMPAO SPECT head	3	For problem solving in HIV/AIDS.	☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative**

Radiologic Procedure	Rating	Comments	RRL*
Thallium-201 SPECT head	3	For problem solving in HIV/AIDS.	☢☢☢☢
Arteriography cervicocerebral	3	For problem solving.	☢☢☢
FDG-PET/CT head	1		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Single focal neurologic deficit, acute onset, progressive.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	8	Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI head without contrast	8	Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses.	O
CT head without contrast	8	Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses.	☢☢☢
MRA head and neck without and with contrast	7	See statement regarding contrast in text under "Anticipated Exceptions."	O
MRA head and neck without contrast	7		O
CTA head and neck with contrast	7		☢☢☢
CT head perfusion with contrast	7		☢☢☢
MRI head perfusion with contrast	7	See statement regarding contrast in text under "Anticipated Exceptions."	O
CT head without and with contrast	6	If MRI is unavailable or contraindicated. Consider CT perfusion.	☢☢☢
CT head with contrast	4		☢☢☢
MR spectroscopy head without contrast	4		O
MRI functional (fMRI) head without contrast	3		O
Tc-99m HMPAO SPECT head	3	For problem solving in HIV/AIDS.	☢☢☢☢
Thallium-201 SPECT head	3	For problem solving in HIV/AIDS.	☢☢☢☢
Arteriography cervicocerebral	3	For problem solving.	☢☢☢
FDG-PET/CT head	1		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 4: Single or multiple focal neurologic deficit, subacute onset, progressive or fluctuating.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	8	See statement regarding contrast in text under	O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative**

Radiologic Procedure	Rating	"Anticipated Exceptions." Comments	RRL*
MRI head without contrast	8		O
CT head without contrast	7	Acute screening	☢☢☢
MRA head and neck without and with contrast	6	See statement regarding contrast in text under "Anticipated Exceptions."	O
MRA head and neck without contrast	6		O
CT head without and with contrast	6	If MRI is unavailable or contraindicated. Consider CT perfusion.	☢☢☢
CTA head and neck with contrast	6	For suspected vascular abnormality.	☢☢☢
CT head perfusion with contrast	5		☢☢☢
MRI head perfusion with contrast	5	See statement regarding contrast in text under "Anticipated Exceptions."	O
CT head with contrast	4		☢☢☢
MR spectroscopy head without contrast	4	For selected cases.	O
MRI functional (fMRI) head without contrast	3		O
Tc-99m HMPAO SPECT head	3	For problem solving in HIV/AIDS.	☢☢☢☢
Thallium-201 SPECT head	3	For problem solving in HIV/AIDS.	☢☢☢☢
Arteriography cervicocerebral	3	For problem solving.	☢☢☢
FDG-PET/CT head	2		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 5: Unexplained acute confusion or altered level of consciousness.

Radiologic Procedure	Rating	Comments	RRL*
MRI head without and with contrast	8	Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI head without contrast	8	Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses.	O
CT head without contrast	8	Both CT and MRI may be necessary. CT screens for suspected hemorrhage in the acute setting and MRI screens for infarction and masses.	☢☢☢
MRA head and neck without and with contrast	6	See statement regarding contrast in the text below under "Anticipated Exceptions."	O
MRA head and neck without contrast	6		O
CTA head and neck with contrast	6	For suspected vascular abnormality.	☢☢☢
CT head without and with contrast	5	If MRI is unavailable or contraindicated. Consider CT perfusion.	☢☢☢
CT head with contrast	4		☢☢☢
MRI functional (fMRI) head without contrast	3		O

Radiologic Procedure	Rating	Comments	RRL*
MR spectroscopy head without contrast	3		O
FDG-PET/CT head	3		☢☢☢☢
Tc-99m HMPAO SPECT head	3		☢☢☢☢
Thallium-201 SPECT head	3		☢☢☢☢
CT head perfusion with contrast	3		☢☢☢
MRI head perfusion with contrast	3		O
Arteriography cervicocerebral	2		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

A focal neurological deficit consists of a set of symptoms or signs in which causation can be localized to an anatomic site within the central nervous system (CNS). The presumed site of the pathologic abnormality within the brain or spinal cord is typically deduced by thoughtful consideration of the patient's history and physical examination prior to imaging. The clinical localization of a suspected lesion is extremely useful (and should be encouraged on the part of the examining physician) in that it assists the radiologist in directing the imaging portion of the evaluation. Focal neurological deficits may develop suddenly or may evolve chronically. Once a deficit occurs, it may remain stable, worsen in a continuous or step-like fashion, or resolve. Resolution may be partial or complete.

Additionally, deficits may be unifocal, implying a single lesion, or multifocal, suggesting multiple discrete lesions. A patient presenting with a focal neurological deficit should be considered for imaging of the appropriate portion of the neuraxis. The presentation may suggest causation. For example, an acute temporal course prompts evaluation for cerebral infarction, but a more chronically progressive course is often due to a mass lesion. Specific disease entities are fully reviewed in separate American College of Radiology (ACR) Appropriateness Criteria® topics. The patient who presents with a focal disorder of motor or sensory function caused by intracranial pathology is addressed in this summary.

Imaging Modalities

Many imaging tools are available to the clinician and radiologist for evaluating the focal neurological deficit. Application of these modalities largely depends on the presumptive or working diagnosis, the urgency of the clinical problem, availability of the modality, and comorbidities of the patient. Modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) may be used as a first-line screening or definitive examination and tend to provide useful and frequently diagnostic anatomic information, whereas modalities such as positron emission tomography (PET), single-photon-emission computed tomography (SPECT), and cervicocerebral catheter angiography are usually reserved for solving more challenging clinical problems. Newer perfusion applications of both CT and MRI have also been proving useful for patients with conditions such as tumors and cerebrovascular disease.

Acute Focal Neurological Deficit

The sudden development of a single focal neurological deficit (see Variant 1 above) suggests a vascular ischemic event such as an infarction. Infarctions typically remain stable in the immediate period of presentation or worsen due to complicating hemorrhage, edema, or infarction extension after hemorrhage (Variant 3). A deficit from a transient ischemic attack resolves within 24-hours (Variant 2). Neurologic deficits from acute reversible ischemia may take up to 30-days to completely resolve.

CT scanning is often used to screen patients for suspected infarction, but it may miss early cytotoxic edema. An obscured insular ribbon and a dense middle artery are signs indicating infarction but may be absent in a given patient. Diffusion-weighted imaging (DWI) MRI detects cytotoxic edema in the first few hours of an infarction and may remain positive for a week to ten days. Spin-echo sequences before and after intravenous enhancement may add significant information as the infarction evolves. During the acute presentation, CT and MR perfusion may add information regarding the ischemic penumbra of an infarction. CT angiography (CTA) may also be useful in evaluating the intra- and extra-cranial blood vessels. Catheter angiography is generally reserved for problem-solving. A detailed summary of ischemic vascular disease is in the National Guideline Clearinghouse (NGC) summary ACR Appropriateness Criteria® cerebrovascular disease.

An intracerebral hemorrhage may also cause sudden onset of focal findings. The clinical examination may help to define the cause of the

hemorrhage. A third cranial nerve palsy with associated abnormal pupillary function and headache, for example, suggests subarachnoid hemorrhage due to aneurysm rupture. Sudden hemiparesis in the setting of hypertension suggests a hemorrhage in the basal ganglia. CT is generally the preferred modality for initial screening for intracranial hemorrhage because of its availability, rapid scanning time, and sensitivity in detecting blood. The newly identified "spot sign" described in patients undergoing CTA in the acute setting may be a useful indicator for prognosis. MRI has been found to be sensitive for both acute and chronic blood products and, when available, can exclude hemorrhage in patients with a suspected infarction before intravenous administration of tissue plasminogen activator (tPA). Moreover, MRI has been shown to be superior to CT in detecting acute petechial hemorrhagic transformation in acute ischemic stroke. A study showed that with appropriate sequence selection, acquisition time of an MRI can be significantly decreased to about 10 to 15 minutes.

Traumatically induced or spontaneous subdural and epidural hematomas may also produce acute focal deficits. CT is the modality of choice for screening patients for suspected extra-axial hemorrhage and for detecting fractures. Surface renderings from CT data may also aid in diagnosis of the latter.

Rarely, Tc-99m hexamethylpropyleneamine-oxime (HMPAO) SPECT may be used for problem-solving in challenging cases of focal neurological deficit, especially in human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) patients.

Subacute Progressive Focal Neurologic Deficit

Progressively worsening focal neurological deficits of subacute onset may be caused by an expanding intracranial lesion such as a primary or metastatic neoplasm (Variant 4). Subacute or more rapidly developing symptoms may be caused by an infectious lesion or expanding vascular malformation. Primary and secondary neoplasms and abscesses may produce progressive weakness, impaired speech, personality change, or a sensory deficit, depending on the location within the brain. Hemiplegia is the most common form of paralysis. Monoplegia and, less commonly, bilateral extremity weakness may also be caused by an intracranial process, although spinal cord and brain stem lesions should also be considered depending on the neurological examination. The cardinal signs of a mass lesion include headache, vomiting, and papilledema. This triad is usually caused by obstructive hydrocephalus or marked peritumoral vasogenic edema. Cranial nerve deficits accompanying contralateral weakness localize pathology to the brainstem.

Imaging studies are performed primarily to detect an intracranial mass lesion, whether neoplastic, infectious, or vascular, and to characterize the offending pathology. Ideally, imaging evaluation should be performed after the patient has undergone a physical examination in order to best direct the imaging protocol and even to clinically exclude a possible extracranial cause for the symptomatology.

CT is invaluable for detecting intracranial tumors, infections, and vascular lesions. A retrospective review found that 20% of elderly patients (>70 years of age) presenting with neurological deficits had treatable lesions discovered with CT. The cohort most affected by the CT imaging was the group with neurological signs that were atypical of stroke and with unexplained confusion or altered sensorium.

Contrast agents yield additional information on CT. An increase in the iodine dose or scan delay time may reveal new lesions and can further increase the conspicuity of some lesions, sometimes yielding supplementary diagnostic information. Current-generation scanners have significantly improved sensitivity; however, some pathology is difficult to visualize with CT under any circumstances. This is especially true for white-matter disease and other lesions that may not produce significant mass effect. Also, compared with its ability to detect intraparenchymal lesions, CT is not as reliable for delineating leptomeningeal or dural disease. Moreover, it is unlikely to be of any benefit in atraumatic patients with neurological deficits that have completely resolved at the time of imaging.

Contrast-enhanced MRI is more sensitive than CT for detecting primary and secondary brain lesions and for defining the extent of disease. Even before the availability of MRI contrast agents, this modality surpassed CT in sensitivity for detecting intraparenchymal pathology. In addition to superior contrast resolution, MRI spares patients exposure to potentially damaging ionizing radiation. It also provides information that is unavailable by other noninvasive means, and sometimes it approaches the accuracy of a neuropathologic diagnosis. Intravenous gadolinium contrast especially increases the detection of intracranial metastatic disease. Contrast agents aid the characterization of primary brain tumors, but they may not be essential for screening examinations. Stratification of patients who should receive contrast based on age may be beneficial. Metastatic disease affects all age groups, but the incidence increases significantly after the fourth decade. More than 75% of patients harboring metastases in the CNS are between 40 and 70 years of age. Gadolinium is better tolerated than iodine, so some centers follow an unenhanced CT scan with an unenhanced and enhanced MR scan. Although high-dose enhanced MRI results in increased lesion contrast, apparent size, and border definition compared with single-dose examinations, concern about nephrogenic systemic fibrosis has dampened enthusiasm for routine use of double- or triple-dose contrast scans, especially in patients with renal disease. Use of agents with greater relaxivity, such as gadobenate dimeglumine, may improve conspicuity of lesions at acceptable dose levels.

MRI is especially useful for evaluating the posterior fossa, a region often less well visualized with CT because of artifact. A posterior fossa mass is suspected in patients presenting with increased intracranial pressure, cerebellar signs, and/or cranial nerve deficits. Brain stem pathology is a potential source for concomitant extremity and cranial nerve deficits. Neoplasms, vascular lesions, and occasionally infections may involve the

pons, midbrain, or medulla. Up to 22% of cavernous malformations occur in the brainstem. MRI is superior not only for detecting of brain stem lesions, but also for characterizing hemorrhagic residua. Brain stem ischemia typically occurs in older adults, and it may rarely affect children. Suspected brain stem and other posterior fossa pathologies argue strongly for MRI over CT because of CT artifact caused by adjacent bony structures. Enhanced MRI is also the modality of choice for patients with cranial neuropathy (see the NGC summary ACR Appropriateness Criteria® cranial neuropathy).

While CT may be preferable for evaluating bony trauma, acute subarachnoid blood, and some head and neck disorders, MRI has become the modality of choice for most CNS disorders. Of course, nonavailability of MRI, MR-incompatible life support apparatus, ferromagnetic aneurysm clips, and other contraindications to MRI will prompt CT even for diseases best evaluated with MRI. Hemorrhagic lesions are characterized more accurately with MRI. Although it is often impossible to distinguish tumoral hemorrhage from other causes on CT, features are often detected on MRI that suggest an underlying malignancy. Although CT is more sensitive for detecting small calcifications associated with vascular malformations, MRI is more sensitive for detecting the small hemorrhagic foci commonly associated with vascular malformations, and it provides a more specific imaging appearance.

Despite the exceptionally good tissue contrast resolution of MRI, the anatomic images may be insufficient for neurosurgeons who are contemplating resection of a lesion that borders eloquent cortex. Distortion of the motor strip and other vital parenchyma may occur secondary to an expanding adjacent mass. The functional plasticity of the brain may not be reflected on conventional anatomic imaging studies. Preoperative (or preradiation) functional MRI (fMRI) for mapping of eloquent cortex more precisely delineates motor and speech areas and may contribute to surgical and treatment planning. Such studies may supplant or accompany intraoperative neurophysiological testing for mapping the motor strip prior to resection of brain tumors. Additional functional information can be provided by diffusion tensor tractography. This method is being used in some centers for mapping the deflection of fibers carrying eloquent signals in the vicinity of the contemplated surgical bed. Such functional studies may also obviate amytal testing.

In previously treated patients with brain neoplasms presenting with new neurological complaints, distinguishing radiation necrosis from tumor recurrence is a diagnostic challenge. These lesions, which may have a similar appearance on enhanced MRI, call for significantly different clinical management. Nuclear medicine SPECT or PET studies may provide improved specificity. However, these modalities are not universally reliable for making this distinction. MR spectroscopy with perfusion may also prove useful for distinguishing radiation necrosis from tumor recurrence. Catheter angiography has traditionally been used to assess tumor vascularity. More recently, evaluation of tumor vascularity using dynamic MRI has been validated.

Localized infection may also produce focal neurological signs and symptoms. Neurological deficits due to infection tend to evolve more quickly than those due to tumor. Patients with parenchymal infectious lesions often have no fever or other systemic signs of infection, and may have a normal cerebrospinal fluid (CSF) profile; if fever is present, it is nonspecific. Brain abscesses may result from a wide variety of organisms, including gram-positive and gram-negative bacteria and various fungi. Blood-borne abscesses may develop in the brain as a result of cyanotic heart disease, pulmonary anterior-venous fistula, or bacterial endocarditis. Direct spread of organisms may also result in brain abscesses as a complication of sinusitis, chronic otitis or mastoiditis, and post-traumatic or congenital transgression of the dura. Intracerebral abscesses may also develop by direct venous spread from extradural infections. An early diagnosis of a brain abscess or its earlier stage of "cerebritis" guides appropriate treatment, including the careful selection of antibiotics, drainage of the abscess cavity, and correction of the original source of the infection, particularly if the abscess is secondary to sinus or middle ear infection.

Since the introduction of CT, the overall mortality rate due to abscesses has decreased from more than 40% to less than 5%. The CT appearance of infectious masses has been well described. Earlier detection in combination with improved therapeutic measures for intracranial infections has produced a significant decrease in complications such as extension to extra-axial spaces, hemorrhage, infarction, compartmental herniation, and death. Although it is less sensitive for detecting small calcifications, MRI provides greater sensitivity for assessing intracranial abscess and granulomas, and may be more specific. However, even in endemic areas, the imaging appearance of such lesions is not specific enough to obviate histological confirmation before treatment.

Contrast-enhanced images augment the sensitivity of CT and noncontrast MR brain imaging. The efficacy of enhanced MRI scans has been demonstrated in children and adults. MRI is superior to CT for evaluating parenchymal abscesses and their complications. It is also more sensitive for evaluating extra-axial infection. MRI demonstrates almost pathognomonic findings in a mature abscess due to the shortening of the T1 and T2 relaxation times in the abscess wall, resulting in hyperintensity on T1-weighted and hypointensity on T2-weighted images. DWI MRI may allow differentiation of brain abscess from necrotic or cystic brain tumors. The ring configuration seen in tumor on spin echo sequences aids in differentiating the finding from the solid, central restricted diffusion seen in an abscess. The restricted diffusion found in extradural epidermoids may be confused with empyema, but correlation with spin echo images and clinical findings is useful.

MRI, and particularly MR venography (MRV), may also be useful for demonstrating secondary venous occlusive disease, a frequent complication of chronic mastoiditis with superimposed acute infection. Despite advances in MRV, catheter cerebral angiography remains the gold standard.

CT is considered superior for demonstrating bone abnormalities in inflammatory ear disease and may also provide useful additional information in cases of sinusitis. CT remains the standard modality for diagnosing sinusitis, but MRI is often necessary to exclude intracranial complications of sinusitis such as meningitis or abscess. CT or MRI is also necessary for stereotactic aspiration of abscess cavities. MR spectroscopy may be useful for demonstrating abscesses because specific resonance peaks have been shown in the contents in the abscess. Conspicuity may be further enhanced by magnetization transfer imaging techniques, although the latter have not been widely adopted in everyday practice.

Patients infected with human immunodeficiency virus (HIV) and those with acquired immunodeficiency syndrome (AIDS) exhibiting focal neurological symptoms should undergo cranial imaging in order to guide clinical management. In addition to contributing to clinical management, imaging findings also have prognostic implications in AIDS patients. The presence of focal lesions or atrophy significantly increases the risk of death in patients with AIDS when compared to AIDS patients with normal neuroimaging examinations. The risk is even greater if both focal lesion and atrophy are present. The treatment for the most common intracranial lesions in these patients must be instituted promptly. MRI is superior to CT for detecting white-matter lesions and vasogenic edema. Despite the excellent ability of MRI to delineate lesions, distinguishing between lesions caused by toxoplasmosis and primary CNS lymphoma is often difficult on the basis of anatomic imaging alone. Some MRI features may favor one diagnosis over the other, but the distinction is often difficult. Although enhanced images have been shown to provide additional information in AIDS patients who present for cranial MRI, the value of routine use of gadolinium contrast agents in AIDS patients has been challenged.

Thallium-201 uptake of lymphoma may be exploited by performing SPECT on AIDS patients presenting with intracranial lesions. Characterizing biochemical profiles of lesions using H-1 spectroscopy may provide another noninvasive and more specific method for differentiating these lesions. Additional information may be obtained from perfusion MRI. Reduced regional cerebral blood volume (rCBV) in toxoplasmosis lesions has been described and compared with increased rCBV in lymphomas, thus allowing differentiation of mass lesions in AIDS patients caused by these diseases.

Chronic subdural hematomas may also produce a step-wise progressive neurological deficit if repetitive rebleeding has occurred. CT is the modality of choice for screening in this circumstance.

Fluctuating Focal Neurological Deficit

Focal neurological deficits that have a stuttering course or localize to multiple locations may be clinically challenging. One etiology is demyelination, most commonly caused by multiple sclerosis (MS) (Variant 4). MS is an inflammatory disease that primarily affects central myelin, secondarily injuring axons and their neurons of origin. Although the mechanisms of injury are still being clarified, MS is considered an organ-specific autoimmune disease. Through a variety of possible mechanisms, including viral infection, a clone of T-cell lymphocytes becomes sensitized to specific myelin peptides. Relapses occur when the activated T-cell lymphocytes increase endothelial cell permeability and recruit macrophages, astrocytes, and other cells to cause focal inflammation and myelin destruction. The management of this disorder has been radically changed recently by the availability of drugs that are effective in improving the natural course of the relapsing-remitting form.

When considering the appropriateness of imaging procedures for diagnosing MS, important factors include: 1) the likelihood that a given clinical presentation represents demyelinating disease or other disorder that can be imaged, and 2) the likelihood that the use of an imaging modality will change the management of the disorder. Up to 40% of patients with proven MS first present with paresthesias or other vague sensory symptoms. Pain can also be the first symptom. These patients often have negative MRI of the brain and spinal cord. Pursuing imaging beyond the standard screening MRI may not be indicated.

The sensitivity of CT of the brain for MS is low. Indirect findings, such as areas of hypodensity or brain atrophy, appear late in the disease and are nonspecific. MRI revolutionized the diagnosis and management of MS, which previously was diagnosed solely by clinical criteria and CSF analysis. In a study comparing high field MRI (1.5T) to low field MRI (0.23T), it was shown that high field studies are far superior for diagnosing MS. As promising new therapies have become available, surveillance with MRI exceeds the neurological examination in sensitivity to disease activity. Sequences such as fluid-attenuated inversion recovery (FLAIR) with fast-spin-echo acquisition and short T1 inversion recovery (STIR) have greatly improved lesion detection.

Brain MRI has been used in large therapeutic trials to monitor MS disease activity. In relapsing-remitting and secondary progressive MS, serial T2-weighted MRI reveals 3 to 10 times as many new lesions as there are clinical relapses. Gadolinium enhancement further increases the reliability and sensitivity of detecting active lesions. In relapsing-remitting and secondary progressive MS, the presence of enhancement is more frequent during relapse and correlates well with clinical activity. Enhancement is rare in primary progressive MS. In benign MS, with a slow progression and little disability, enhancing lesions are also rare. Delayed scanning and magnetization transfer may improve sensitivity.

MR spectroscopy may help clarify the pathophysiology underlying the diverse varieties of MS. Metabolic changes have been observed on MR spectroscopy before the appearance of lesions on MRI, but these applications have little utility in clinical practice at this time.

Unexplained Acute Confusion or Altered Level of Consciousness

Although confusion and altered level of consciousness are not considered focal neurological phenomena, these presentations are all too common in the field of emergency medicine and will be briefly discussed here (Variant 5).

Impaired consciousness may range from mild inattention and clouding of the sensorium to stupor and coma. Substance intoxication, trauma, and cerebrovascular disease are frequent causes of coma in the typical large urban hospital. Unenhanced CT remains a reliable screening modality in this setting and is especially good when hemorrhage is suspected. Certainly, further evaluation with MRI including DWI may be useful. MRI better characterizes infarction and masses as previously noted. In cases of metabolic derangement such as uncontrolled diabetes mellitus or alcoholism, CT may evaluate for suspected trauma that may be associated with the metabolic condition. Advanced imaging studies such as fMRI, MR spectroscopy, fluorine-18-2-fluoro-2-deoxy-D-glucose-positron emission tomography (FDG-PET), Tc-99m HMPAO SPECT, and thallium-201 SPECT have little use in the acute setting, but may have limited application as problem-solving techniques.

Summary

- Focal neurologic deficits typically localize to an anatomic site within the CNS and often point to a specific etiology such as ischemic cerebrovascular disease, hemorrhage, tumor, or abscess.
- Imaging evaluation of focal neurologic deficits is best performed in concert with a detailed clinical assessment.
- CT and MRI may be used as a first-line screening or definitive examination and tend to provide useful and frequently diagnostic anatomic information.
- Modalities such as PET, SPECT, and cervicocerebral catheter angiography are usually reserved for solving more challenging clinical problems.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73 m^2), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73 m^2. For more information, please see the American College of Radiology (ACR) Manual on Contrast Media (see the "Availability of Companion Documents" field).

Abbreviations

- AIDS, acquired immunodeficiency syndrome
- CT, computed tomography
- CTA, computed tomography angiography
- FDG-PET, fluorine-18-2-fluoro-2-deoxy-D-glucose-positron emission tomography
- HIV, human immunodeficiency virus
- HMPAO, hexamethylpropyleneamine oxime
- MRA, magnetic resonance angiography
- MRI, magnetic resonance imaging
- SPECT, single-proton emission computed tomography
- Tc, technetium

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Focal neurologic deficit

Guideline Category

Diagnosis

Evaluation

Clinical Specialty

Family Practice

Internal Medicine

Neurology

Nuclear Medicine

Radiology

Intended Users

Health Plans

Hospitals

Managed Care Organizations

Physicians

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of initial radiologic examinations for patients with focal neurologic deficit

Target Population

Patients who present with a focal neurologic deficit

Interventions and Practices Considered

1. Magnetic resonance imaging (MRI)
    - Head without and with contrast
    - Head without contrast
    - Head perfusion with contrast
    - Functional (fMRI) head without contrast
2. Computed tomography (CT)
    - Head with contrast
    - Head without contrast
    - Head without and with contrast
    - Head perfusion with contrast
3. MR angiography (MRA) head and neck
    - Without contrast
    - Without and with contrast
4. MR spectroscopy head without contrast
5. CT angiography (CTA) head and neck with contrast
6. Technetium (Tc)-99m hexamethylpropyleneamine oxime (HMPAO) single-photon emission computed tomography (SPECT) head
7. Arteriography cervicocerebral
8. Fluorine-18-2-fluoro-2-deoxy-D-glucose-positron emission tomography (FDG-PET)/CT head
9. Thallium-201 SPECT head

Major Outcomes Considered

Utility of radiologic examinations in differential diagnosis

Methodology

Methods Used to Collect/Select the Evidence

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Procedure

The Medline literature search is based on keywords provided by the topic author. The two general classes of keywords are those related to the condition (e.g., ankle pain, fever) and those that describe the diagnostic or therapeutic intervention of interest (e.g., mammography, MRI).

The search terms and parameters are manipulated to produce the most relevant, current evidence to address the American College of Radiology Appropriateness Criteria (ACR AC) topic being reviewed or developed. Combining the clinical conditions and diagnostic modalities or therapeutic procedures narrows the search to be relevant to the topic. Exploding the term "diagnostic imaging" captures relevant results for diagnostic topics.

The following criteria/limits are used in the searches.

1. Articles that have abstracts available and are concerned with humans.
2. Restrict the search to the year prior to the last topic update or in some cases the author of the topic may specify which year range to use in the search. For new topics, the year range is restricted to the last 5 years unless the topic author provides other instructions.
3. May restrict the search to Adults only or Pediatrics only.
4. Articles consisting of only summaries or case reports are often excluded from final results.

The search strategy may be revised to improve the output as needed.

Number of Source Documents

The total number of source documents identified as the result of the literature search is not known.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Strength of Evidence Key

Category 1 - The conclusions of the study are valid and strongly supported by study design, analysis and results.

Category 2 - The conclusions of the study are likely valid, but study design does not permit certainty.

Category 3 - The conclusions of the study may be valid but the evidence supporting the conclusions is inconclusive or equivocal.

Category 4 - The conclusions of the study may not be valid because the evidence may not be reliable given the study design or analysis.

Methods Used to Analyze the Evidence

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author drafts or revises the narrative text summarizing the evidence found in the literature. American College of Radiology (ACR) staff draft an evidence table based on the analysis of the selected literature. These tables rate the strength of the evidence for all articles included in the narrative text.

The expert panel reviews the narrative text, evidence table, and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the table. Each individual panel member forms his/her own opinion based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

Modified Delphi Technique

The appropriateness ratings for each of the procedures included in the Appropriateness Criteria topics are determined using a modified Delphi methodology. A series of surveys are conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. American College of Radiology (ACR) staff distributes surveys to the panelists along with the evidence table and narrative. Each panelist interprets the available evidence and rates each procedure. The surveys are completed by panelists without consulting other panelists. The ratings are a scale between 1 and 9, which is further divided into three categories: 1, 2, or 3 is defined as "usually not appropriate"; 4, 5, or 6 is defined as "may be appropriate"; and 7, 8, or 9 is defined as "usually appropriate." Each panel member assigns one rating for each procedure per survey round. The surveys are collected and the results are tabulated, de-identified and redistributed after each round. A maximum of three rounds are conducted. The modified Delphi technique

enables each panelist to express individual interpretations of the evidence and his or her expert opinion without excessive bias from fellow panelists in a simple, standardized and economical process.

Consensus among the panel members must be achieved to determine the final rating for each procedure. Consensus is defined as eighty percent (80%) agreement within a rating category. The final rating is determined by the median of all the ratings once consensus has been reached. Up to three rating rounds are conducted to achieve consensus.

If consensus is not reached, the panel is convened by conference call. The strengths and weaknesses of each imaging procedure that has not reached consensus are discussed and a final rating is proposed. If the panelists on the call agree, the rating is accepted as the panel's consensus. The document is circulated to all the panelists to make the final determination. If consensus cannot be reached on the call or when the document is circulated, "No consensus" appears in the rating column and the reasons for this decision are added to the comment sections.

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current literature and expert panel consensus.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

Selection of appropriate radiologic imaging procedures for evaluation of patients with focal neurologic deficit

Potential Harms

Computed tomography (CT) is associated with potentially damaging ionizing radiation.

Relative Radiation Level (RRL)

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to

estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the American College of Radiology (ACR) Appropriateness Criteria® Radiation Dose Assessment Introduction document (see "Availability of Companion Documents" field).

Gadolinium-based Contrast Agents

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (i.e., <30 mL/min/1.73 m^2), and almost never in other patients. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73 m^2. For more information, please see the ACR Manual on Contrast Media (see the "Availability of Companion Documents" field).

Qualifying Statements

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An American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Living with Illness

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Wippold FJ, Cornelius RS, Aiken AH, Amin-Hanjani S, Berger KL, Broderick DF, Davis PC, Douglas AC, Hoh BL, Mechtler LL, Smirniotopoulos JG, Expert Panel on Neurologic Imaging. ACR Appropriateness CriteriaÂ® focal neurologic deficit. [online publication]. Reston (VA): American College of Radiology (ACR); 2012. 11 p. [44 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2006 (revised 2012)

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

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Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Neurologic Imaging

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Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Wippold FJ II, Brunberg JA, Cornelius RS, Davis PC, De La Paz RL, Dormont D, Gray L, Jordan JE,

Mukherji SK, Seidenwurm DJ, Turski PA, Zimmerman RD, Sloan MA, Expert Panel on Neurologic Imaging. ACR Appropriateness Criteria® focal neurologic deficit. [online publication]. Reston (VA): American College of Radiology (ACR); 2008. 11 p. [41 references]

Guideline Availability

Electronic copies: Available from the American College of Radiology (ACR) Web site.

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 1 p. Electronic copies: Available in Portable Document Format (PDF) from the ACR Web site.
- ACR Appropriateness Criteria®. Evidence table development – diagnostic studies. Reston (VA): American College of Radiology; 2013 Nov. 3 p. Electronic copies: Available in PDF from the ACR Web site.
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the ACR Web site.
- ACR Appropriateness Criteria®. Manual on contrast media. Reston (VA): American College of Radiology; 92 p. Electronic copies: Available in PDF from the ACR Web site.
- ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 1 p. Electronic copies: Available in PDF from the ACR Web site.
- ACR Appropriateness Criteria® focal neurologic deficit. Evidence table. Reston (VA): American College of Radiology; 16 p. Electronic copies: Available from the ACR Web site.

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI on September 6, 2006. This summary was updated by ECRI Institute on May 17, 2007 following the U.S. Food and Drug Administration (FDA) advisory on Gadolinium-based contrast agents. This summary was updated by ECRI Institute on June 20, 2007 following the U.S. Food and Drug Administration (FDA) advisory on gadolinium-based contrast agents. This summary was updated by ECRI Institute on June 30, 2009. This summary was updated by ECRI Institute on January 13, 2011 following the U.S. Food and Drug Administration (FDA) advisory on gadolinium-based contrast agents. This NGC summary was updated by ECRI Institute on September 13, 2012.

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